EXCEPTION REQUESTED FOR PUBLICATION AS A NASA PUBLICATION

This is a brief technical note. It covers only one sounding rocket firing

for which sufficient detailed information was available to make a comparison

between theoretical and actual performance. This meager information does not

warrant the publication as a NASA publication. However, potential experimenters

who are likely to use the Nike-Apache should be permitted the opportunity to

evaluate the results of an actual firing and establish the degree of predict-

ability and, hence, confidence in this Sounding Rocket's performance.

COMPARISON OF THEORETICAL WITH ACTUAL NIKE-APACHE SOUNDING ROCKET PERFORMANCE

D. W. DEMBROW AND L. B. JAMIESON [1963]

Introduction -- The Nike-Apache vehicle (see Figure 1) is a two-stage

unguided sounding rocket consisting of a Nike booster for the first stage and

an Apache second stage. It has been recently added to the NASA repertoire of

sounding rockets and described in detail in References 1 and 2.

Nike-Apache, NASA No. 14.108 GI, was fired at Wallops Island, Virginia,

on March 9, 1963. The vehicle was equipped with telemetry turnstile antennae

and carried a 76 pound payload. The launcher was set at 108° azimuth and

75.7^o elevation to correct for wind, the proposed launch angle being 80°.

The actual trajectory, as determined from radar plots, was compared with

theoretical trajectories computed for the Nike-Apache using the given payload,

weights, thrusts, and drag conditions. This comparison indicates that the

effective launch angle was slightly more than 83°.

The actual trajectory was obtained by smoothing measurements from two

separate radar plots. Corrections were made for the distance between the

radar sites, but not for the distance from the radar sites to the launch site

(about 1/2 mile). The theoretical trajectory was determined by extrapolation

from a series of computed trajectories having sea level launch angles ranging

from 76 to 82° in 2° intervals to obtain the 83° launch angle equivalent.

The theoretical trajectories were computed using the equations of motion

applying zero-lift, no-wind conditions for a spherical, non-rotating earth --

i.e., weight, thrust, and drag. A computer program applying an n-stage two-

dimensional point mass method was used on an IBM 7094 computer to compute

point-by-point values of the theoretical trajectory. The following conditions

applied:

Phase 1 -- Nike Boost

        Gross launch weight - 1611.5 pounds

        Sea level launch

        Nike burning time - 3.5 seconds

        Constant thrust

        Constant mass flow rate

        Drag during burning (see Figure 3)

        Separation at end of Nike burning

Phase 2 -- Apache Coasting

        Coast for 16.5 seconds after separation

        Drag during coast phase (see Figure 4)

Phase 3 -- Apache Burning

        Weight at 2nd stage ignition - 293.5 pounds

        Ignition 20 seconds after lift-off

        Burning time - 6.4 seconds

        Variable thrust (see Figure 5)

        Drag during burning (see Figure 4)

Phase 4 -- Apache Coasting

        Drag, same as Phase 2

        Atmospheric limit - 400,000 feet ARDC 1959

Results -- The results are shown in Figure 2. It can be seen that the
actual and theoretical trajectories disagree slightly. The peak altitude of
the theoretical trajectory is higher than the actual by about 3 1/2 miles in
about 100 miles. The results of other investigators who have computed theo-
retical trajectories for the Nike-Apache Sounding Rocket and their predicted

altitudes are also shown in Figure 2. The results from Reference 1 would have predicted about nine miles higher than the actual peak altitude. The results' estimated from Reference 2 (when adjusted for the additional drag of turnstile antennae) would be around 20 miles higher than the actual peak altitude.

Reference 1 -- Nike-Apache Performance Handbook

NASA GSFC X616-62-103

Reference 2 -- Performance Summary for the Nike-Apache

Sounding Rocket Vehicle

Report No. AST/E1R-00.93

Chance Vought - Under Contract NASA-1-1013

NOSE
BOOSTER
154"

d : 16.5"

APACHE
MOTOR
109"

d : 6.5"

PAYLOAD
COMPARTMENT
VARIABLE

NOSE
CONE
34"
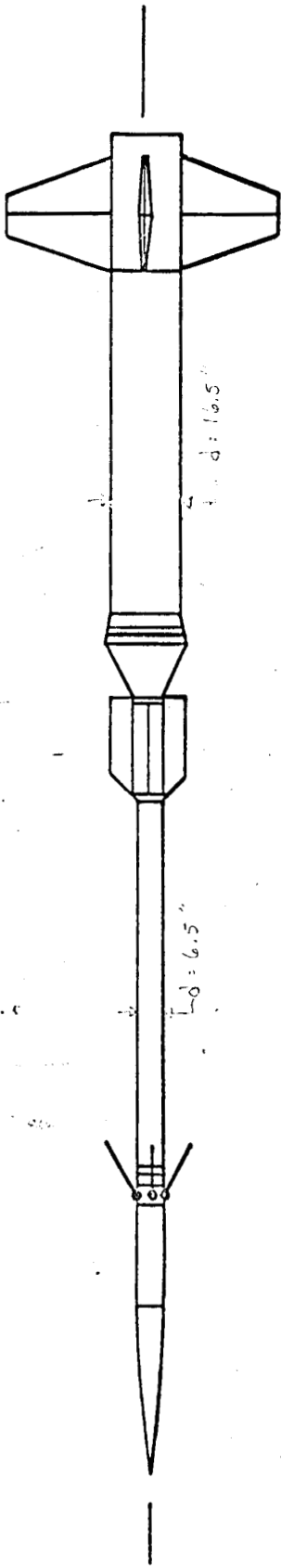
(LENGTHS TO NEAREST INCH)

FIG. 1   NIKE APACHE

Fig 1.
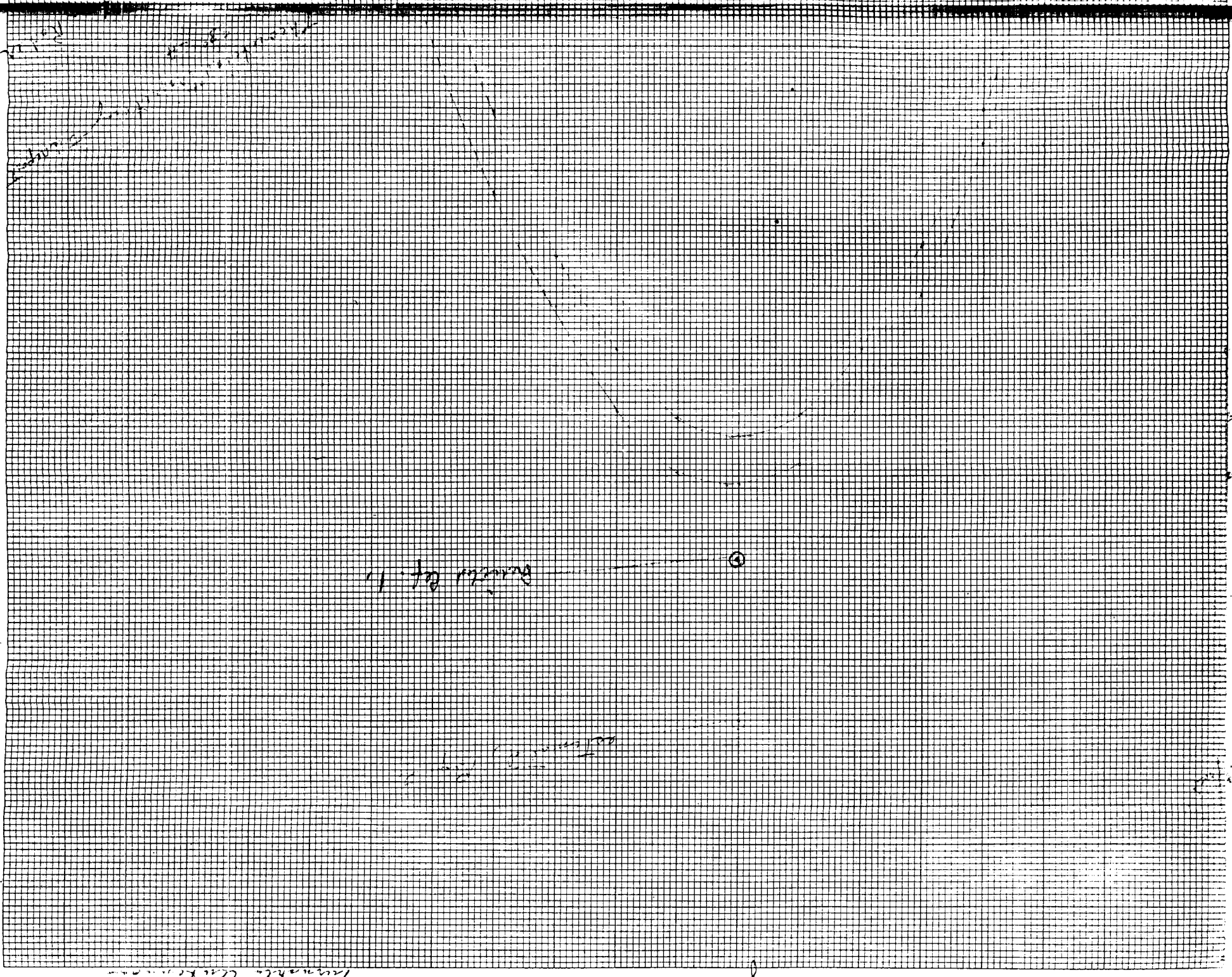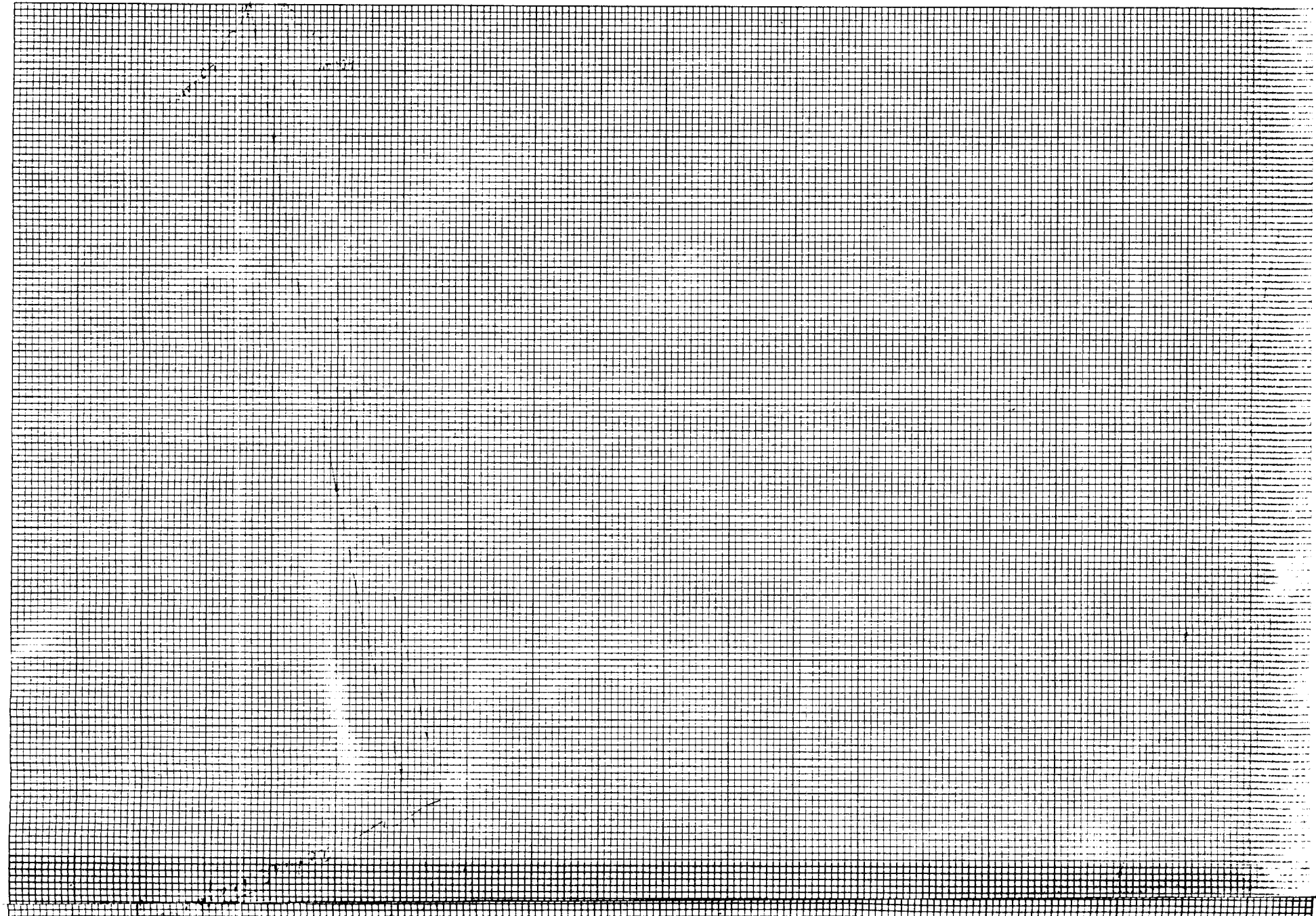
$C_D S$ vs Mach number, Nike, burning
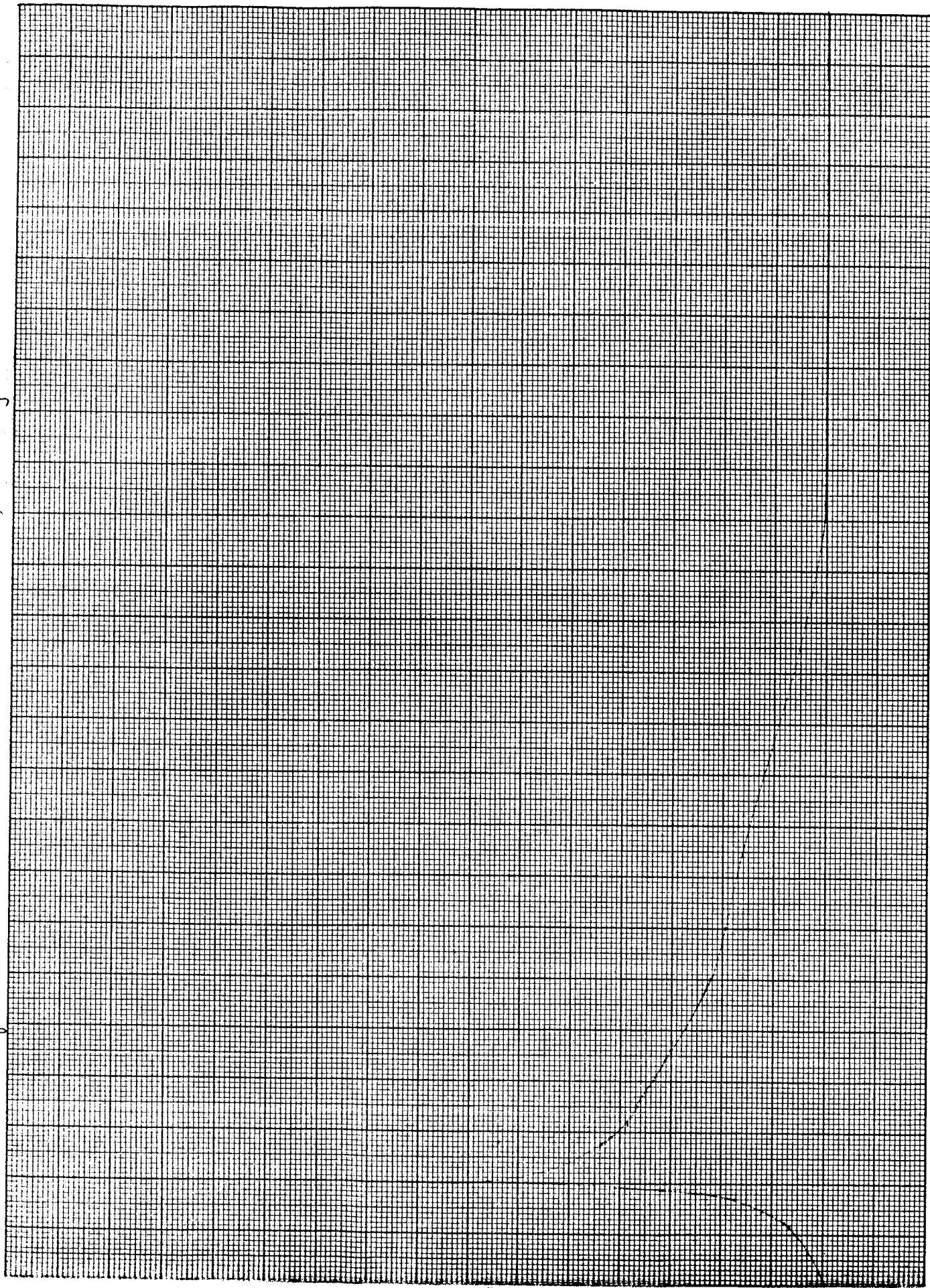
Mach number

Fig 3F   Gos vs. Mach Number, Apache, turnstile antennae

Mach number
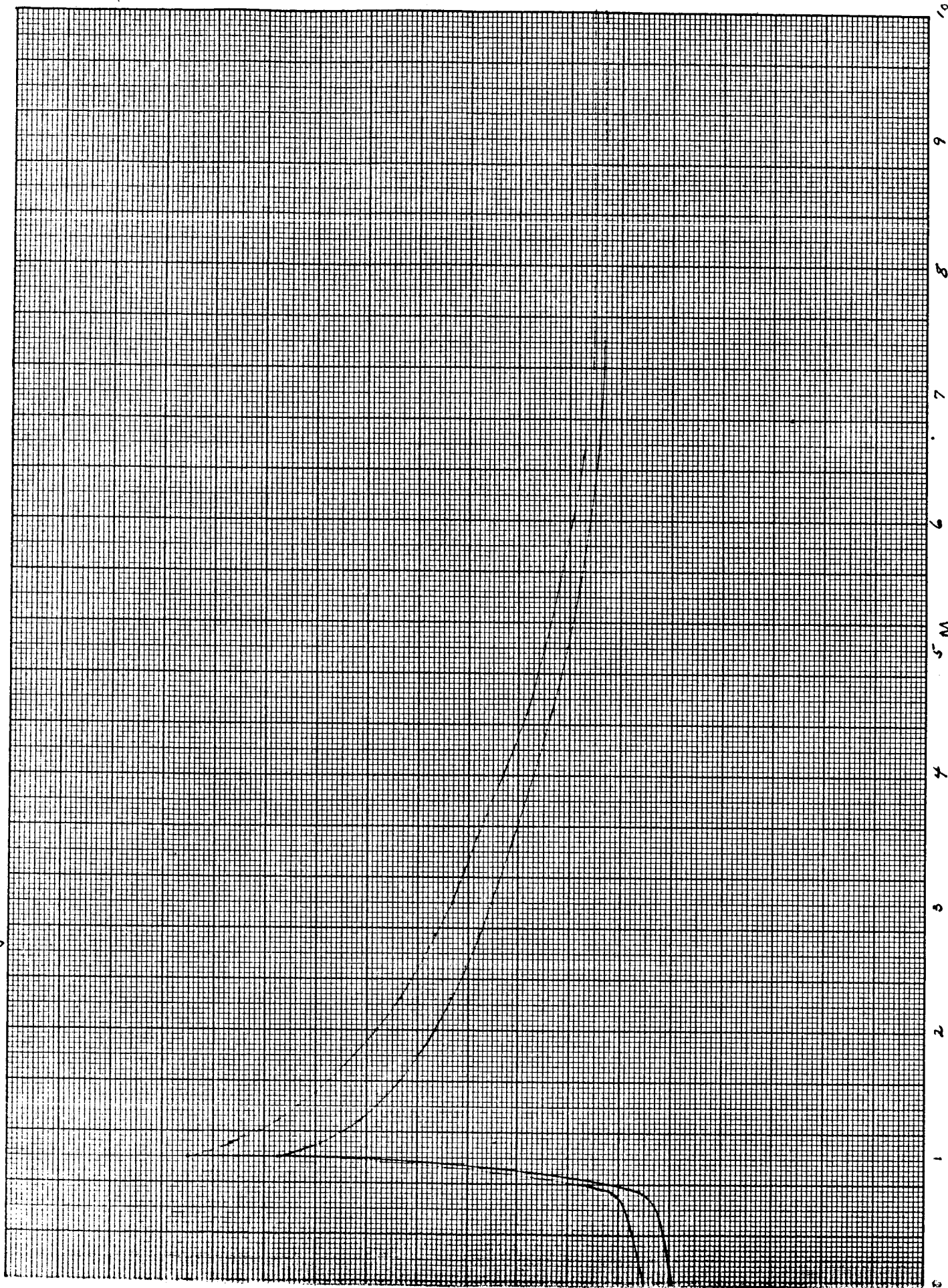
Fig. 5 Apache Thrust curve.

T

Time, sec.

7000
6000
5000
4000
3000
2000
1000
0

0 1 2 3 4 5 6 7 8 9 10